

**Lower Eight Miles of the Lower Passaic River
Remedial Investigation and Focused Feasibility Study
Summary for Community Advisory Group**

The following summary of the Remedial Investigation and Focused Feasibility Study (RI/FFS) for the lower eight miles of the Lower Passaic River is provided to the Passaic River Community Advisory Group to aid the group in preparing its submission to the National Remedy Review Board. Since the RI/FFS reports are still being developed, the information in this summary is current as of October 12, 2012. As work on the RI/FFS progresses, the information may be updated and modified. This document should not be relied on as a summary of the final RI/FFS.

Remedial Investigation (RI) Overview

During a comprehensive study of the Lower Passaic River, an Operable Unit of the Diamond Alkali Superfund Site, the sediments of the lower eight miles were found to be a major source of contamination to the Lower Passaic River and Newark Bay. Therefore, the United States Environmental Protection Agency (USEPA) completed a Focused Feasibility Study (FFS) to evaluate taking action to address those sediments, while the 17-mile Lower Passaic River Study Area (LPRSA) Remedial Investigation/Feasibility Study (RI/FS) is on-going. The FFS and LPRSA RI/FS are being conducted as part of the Lower Passaic River Restoration Project, a comprehensive study of the Lower Passaic River, in cooperation with a group of Partner Agencies: U.S. Army Corps of Engineers (USACE), New Jersey Department of Environmental Protection (NJDEP), National Oceanic and Atmospheric Administration (NOAA) and U.S. Fish and Wildlife Service (USFWS).

The RI report synthesizes a large body of data collected from 1990 through 2011 to: 1) characterize the nature and extent of contamination in the lower eight miles of the Lower Passaic River (FFS Study Area); 2) describe the mechanisms governing long-term fate and transport of the contaminants, and 3) calculate human health and ecological risks to support the analysis of remedial alternatives developed in a companion FFS report.

The RI demonstrates that there are high concentrations of persistent and bioaccumulative contaminants widespread throughout the sediments of the FFS Study Area that are causing unacceptably high human health and ecological risks to humans and biota that are exposed to those contaminants through the sediments or food-chain. Also, the highly-contaminated sediments in the FFS Study Area are being resuspended through tidal action and storm events, and migrating to Newark Bay and the New York-New Jersey Harbor Estuary. The RI shows that other sources, such as the Upper Passaic River, Newark Bay, tributaries, combined sewer

overflows (CSOs) and storm water outfalls (SWOs), are not significant contributors of contamination (for most risk drivers) to the FFS Study Area, when compared to the resuspension of legacy sediments in the main stem of the FFS Study Area. Therefore, the FFS report focuses on remedial alternatives for an action to address the sediments of the FFS Study Area.

Site Background and Sediment Contamination

The FFS Study Area is the lower eight miles of Lower Passaic River in northeastern New Jersey (NJ), from the river's confluence with Newark Bay at River Mile (RM) 0 to RM8.3 near the border between the City of Newark and Belleville Township. The FFS Study Area is located within the LPRSA, which is the 17-mile, tidal portion of the Passaic River from Dundee Dam (located at RM17.4) to the confluence with Newark Bay at RM0 and its watershed, including the Saddle River, Third River and Second River (only the Second River flows into the FFS Study Area) [Figure 1-1].

The Passaic River was one of the major centers of the American industrial revolution starting two centuries ago. By the end of the 19th century, a multitude of industrial operations, such as manufactured gas plants, paper manufacturing and recycling facilities, petroleum refineries, pharmaceutical and chemical manufacturers, and others, had sprung up along the river's banks, as the cities of Newark and Paterson, NJ grew. These industries and municipalities often discharged waste water directly to the river. Over 100 of the industrial facilities have been identified as potentially responsible for discharging a number of contaminants to the river, including, but not limited to, PCDD/F, PCB mixtures, PAH compounds, DDT¹ and other pesticides, mercury, lead and other metals. About 70 companies that operated those facilities have formed the Cooperating Parties Group (CPG) and signed an agreement with USEPA to perform a RI/FS for the LPRSA under USEPA oversight. In addition to various industrial and municipal discharges, the river was significantly impacted by discharges from the manufacturing facility located at 80-120 Lister Avenue in Newark, NJ (RM3), which began producing DDT and other products in the 1940s. Between 1951 and 1969, the facility was operated by Diamond Alkali Company (later purchased by and merged into Occidental Chemical Corporation [OCC]), which used the facility for the production of the defoliant chemical known

¹ Polychlorinated dibenzodioxins and furans (PCDD/F), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), dichlorodiphenyltrichloroethane (DDT). DDT is a common name that refers to an industrially-produced, chlorinated pesticide. Its metabolites include dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyldichloroethylene (DDE). The term Total DDT refers the sum of the DDT, DDD, and DDE concentrations in a sample.

as “Agent Orange”, among other products. A by-product of this manufacturing process was 2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-TCDD), which was released into the river.

The Lower Passaic River has an authorized navigation channel from RM0 to RM15.4, which was constructed by USACE at the end of the 19th century, then sporadically maintained through the 1950s above RM2 and through 1983 below RM2. As maintenance dredging declined and stopped, the navigation channel filled with sediments. At the same time, industrial activities along the river grew, and industries and municipalities disposed of waste waters in the river. The coincidence of chemical disposal in the river, along with the filling-in of the navigation channel, created an ideal situation for the accumulation of contaminated sediments in the Lower Passaic River.

The river’s cross-sectional area declines steadily from RM0 to RM17.4, with a pronounced constriction at RM8.3. At that location, a change in sediment texture is also observed. The river bed below RM8.3 is dominated by silt material with pockets of silt and sand mixtures. Above RM8.3, the bed is characterized by coarser sediments with smaller areas of silt, often located outside the channel. About 85 percent of the silt surface area in the Lower Passaic River is located below RM8.3, and by volume, about 90 percent of silts in the Lower Passaic River are located below RM8.3.

The contaminants of potential concern and contaminants of potential ecological concern (COPCs and COPECs; see below) are hydrophobic² and tend to bind tightly to the organic carbon on fine sediment particles (*i.e.*, silts). Therefore, the highest concentrations of COPCs and COPECs tend to be found in areas that are predominantly comprised of silts, which, for the Lower Passaic River, are the lower eight miles, the FFS Study Area.

Datasets Used in the RI

The RI evaluated data from numerous investigations conducted in the Lower Passaic River and Newark Bay from 1990 to 2011 by academic institutions, state and federal agencies (including USACE and New Jersey Department of Transportation data collected for the comprehensive Lower Passaic River Restoration Project), and potentially responsible parties under USEPA oversight, such as the CPG and Tierra Solutions, Inc. (TSI). The investigations include sediment chemistry, hydrodynamics, sediment transport, bathymetry, geophysical and geotechnical surveys, water column chemistry, and ecological studies (benthic surveys, fish and crab tissue chemistry, habitat identification and avian community surveys).

² To be hydrophobic is to have little or no affinity for water.

Nature and Extent of Contamination

Although a large number of contaminants are found in the FFS Study Area, the RI focuses on those that pose the greatest risks to human and ecological health. The COPCs and COPECs are the following:

Surface Sediments, 0-6 inches	Minimum	Maximum	Mean	Median
2,3,7,8-TCDD (pg/g)	0.09	13,500	597	276
Total TCDD (pg/g)	2.2	13,300 ³	733	394
Total PCBs (µg/kg)	0.1	17,200	1,267	971
Total DDx (µg/kg)	1.9	10,229	250	99.6
Dieldrin (µg/kg)	0.01	152	12.6	5.5
Chlordane (µg/kg)	0.05	254	34.9	26.1
Total PAHs (mg/kg)	0.21	2,806	46.9	29.9
Mercury (mg/kg)	0.05	13.4	2.5	2.3
Copper (mg/kg)	11.5	2,470	182	173
Lead (mg/kg)	4.4	763	257	242

pg/g = picograms per gram or part per trillion (ppt); µg/kg = micrograms per kilogram or part per billion (ppb); mg/kg = milligrams per kilogram or part per million (ppm)

The Lower Passaic River is a partially-stratified estuary with a tidally-driven salt wedge that pushes upstream from Newark Bay into the river, under a top layer of freshwater flowing in from the Upper Passaic River over Dundee Dam. In front of the salt wedge is a cloud of suspended sediments called an estuarine turbidity maximum (ETM). During low flow conditions, the salt wedge and ETM reach as far upstream as approximately RM12, while during storm events, they may be pushed out to Newark Bay. Under typical flow conditions, the salt wedge and ETM are usually located between RM2 and RM10, and move back and forth along about 4 miles of the river each tidal cycle (twice a day). The movement of the salt wedge and ETM mixes the surface sediments, so that, while there is a broad range of concentration values (more than an order of magnitude), there is little or no trend in COPC and COPEC median

³ This value is based on 1995 data reported by Tierra Solutions, Inc. The maximum concentration for Total TCDD should be higher than the maximum concentration for 2,3,7,8-TCDD.

concentrations with river mile in RM2 to RM12 (Figures 4-3, 4-12, 4-17b, 4-32b, 4-47b). Recall that 85 percent of fine sediment surface area and 90 percent by volume of fine sediments are located in the FFS Study Area, so that there is much less contaminated silt above RM8.3 than below RM 8.3, even though median surface concentrations in RM2 to RM12 are very similar.

When maintenance dredging stopped in the 1930s-1950s (above RM2) to 1983 (between RM0 and RM2), sediment infilling rates in the deep anthropogenic channel were relatively high (approximately 4 in/yr). Since the 2000s, however, the deep channel has filled in and the river has begun to reach a quasi-steady state, with overall patterns of infilling slowing considerably and alternating with some scouring during high flow events. This condition means that the river is not steadily filling with “cleaner” sediments from elsewhere, but rather that legacy⁴ sediments are uncovered and resuspended periodically by scouring during high flow events, so that contaminant concentrations in the surface sediments have remained approximately the same in recent years. Sampling in 1995 through 2010 confirms that FFS Study Area surface sediment median contaminant concentrations have remained almost unchanged over the 15-year period (Figures 4-4, 4-13, 4-20, 4-35, 4-52).

As mentioned above, the coincidence of chemical disposal in the river, along with the filling-in of the navigation channel when maintenance dredging stopped, created an ideal situation for the accumulation of contaminated sediments in the Lower Passaic River. Since many industrial discharges were most active in the decades when the navigation channel was first filling in, the highest contaminant concentrations tend to be found deeper down into the sediment bed (Figure 4-75). The total inventory of contaminated sediments in the FFS Study Area is approximately 9.6 million cubic yards (cy).

⁴ The term “legacy sediments” is used to refer to contaminated sediments deposited in the river during the period that it was filling in, and that are the legacy of the long history of industrial and municipal discharges to the river.

Contaminant Concentrations in Sediment with Depth	0.5 - 1.5 ft		1.5 - 2.5 ft		2.5 - 3.5 ft		3.5 ft – bottom of core	
	Min-Max	Mean (Median)	Min-Max	Mean (Median)	Min-Max	Mean (Median)	Min-Max	Mean (Median)
2,3,7,8-TCDD (pg/g or ppt)	0.29 - 50,400	1,820 (410)	0.26 - 78,000	3,980 (520)	0.46 - 932,000	10,000 (450)	0.07 - 5,300,000	19,400 (270)
Total TCDD (pg/g or ppt)	0.032 - 27,700	1,590 (430)	0.11 - 60,200	3,400 (580)	0.021 - 67,900	3,700 (580)	0.021 - 2,700,000	12,500 (370)
Total PCBs (ug/kg or ppb)	0.15 - 33,000	2,900 (1,460)	0.33 - 18,800	3,300 (1,700)	0.0062 - 30,000	3,900 (1,600)	0.00059 - 130,000	3,300 (920)
Total DDx (ug/kg or ppb)	0.21 - 1,820	220 (120)	0.065 - 30,800	680 (130)	0.02 - 7,800	460 (180)	0.0038 - 14,000,000	29,500 (120)
Dieldrin (ug/kg or ppb)	0.03 - 250	18 (4.6)	0.026 - 250	21 (4.6)	0.0014 - 580	25 (4)	0.0016 - 1,000	27 (3)
Chlordane (ug/kg or ppb)	0.10 - 180	48 (42)	0.053 - 220	51 (46)	0.0037 - 290	59 (43)	0.0023 - 240	34 (10)
Total PAHs (mg/kg or ppm)	0.006 - 350	35 (24)	0.0013 - 7,800	99 (27)	0.0011 - 720	45 (29)	0.00032 - 1,300	65 (33)
Mercury (mg/kg or ppm)	0.0034 - 28	4.4 (3.5)	0.017 - 30	5.8 (4.2)	0.01 - 28	5.9 (4.7)	0.0016 - 30	6.6 (5.4)
Copper (mg/kg or ppm)	1.5 - 3,000	260 (210)	3.4 - 790	280 (230)	2.3 - 1,040	280 (280)	2.1 - 4,700	330 (310)
Lead (mg/kg or ppm)	1.9 - 17,900	490 (340)	1.7 - 1,040	420 (390)	1.7 - 980	400 (420)	1.0 - 7,900	430 (460)

Contaminant Fate and Transport

The COPCs and COPECs are persistent in the environment and highly particle-reactive (meaning they are readily adsorbed onto the surface of sediment grains); therefore, the movement of suspended sediments in the estuary controls the sources, fate, and transport of these contaminants. The RI also discusses chemical properties of the COPCs and COPECs that affect how they move through the environment among the sediment bed, water column, atmosphere and biota.

Resuspension of FFS Study Area sediments as a result of tidal activity and scouring during high flow events is the primary ongoing source of COPCs and COPECs to the water column and surface sediments of the FFS Study Area. Data and screening-level analyses show that other contributors have relatively smaller impacts, although some may still be important. The other sources evaluated in the RI are the Upper Passaic River, Newark Bay, tributaries (mainly Saddle River, Third River and Second River), CSOs and SWOs, industrial point sources along the main stem of the river, atmospheric deposition and groundwater.

The results of USEPA's analyses show that, currently, atmospheric deposition, groundwater discharge, and industrial point sources are not significant contributors of sediments and the contaminants bound to them to the FFS Study Area. Upper Passaic River, Newark Bay, the three main tributaries, and CSOs and SWOs were sampled from 2005 to 2011, and an Empirical Mass Balance (EMB) model of suspended sediment and contaminant loads was performed with the data. Resulting suspended and recently-deposited⁵ sediment concentrations show that the tributaries, CSOs, and SWOs are minor contributors of COPCs, since their flows are minor compared to those of the Upper Passaic River and Newark Bay, and their contaminant concentrations are lower compared to the surface sediments of the Lower Passaic River main stem. Contributions from the various sources are summarized below.

Contribution of Various Sources to Recently-Deposited Surface Sediments of Lower Passaic River

	Upper Passaic River (percent)	Newark Bay (percent)	Tributaries (percent)	CSOs-SWOs (percent)	Lower Passaic River Resuspension (percent)
Solids	32	14	6	1	48
2,3,7,8-TCDD	0	3	0	0	97
Total TCDD	3	5	0	0	92
Total PCBs	11	6	1	0	81
DDE	10	8	3	1	78
Copper	14	12	1	1	72
Mercury	11	14	0	0	75
Lead	19	7	2	2	71
Chlordane	32	3	11	3	52
Benzo(a)pyrene	53	7	5	1	33
Fluoranthene	47	5	6	2	40

Sediment and Contaminant Transport Mechanistic Modeling

A mechanistic model (Lower Passaic River-Newark Bay [LPR-NB] Model) was developed largely from an existing New York/New Jersey (NY/NJ) Harbor-wide model⁶ to understand the complex fate and transport of contaminants in the estuary and to predict future sediment and surface water contaminant concentrations under various remedial alternatives. The LPR-NB Model consists of a series of linked hydrodynamic, sediment transport, organic carbon and

⁵ Sampling conducted for the FFS demonstrated that recently-deposited sediments (Be-7 bearing) are representative of the time-averaged suspended sediments in the water column above them.

⁶ Contaminant Assessment and Reduction Program (CARP) model.

contaminant fate and transport models. Sediment transport was studied extensively and modeled using a directly coupled model for hydrodynamics and sediment transport (Estuarine, Coastal and Ocean Model with SEDZLJS submodel [ECOM-SEDZLJS]). The sediment bed and bed-water column exchanges of solids were described by the SEDZLJS sediment submodel, which incorporated consolidation⁷ effects in deposited cohesive sediment⁸ layers integrated into the bed model SEDZLJ.

Contaminant transport was described by an organic carbon cycling model (Sediment Transport System-Wide Eutrophication Model [ST-SWEM]) and a toxic constituent fate and transport model (Row Column Aesop Toxics [RCATOX]), incorporating the sediment transport model described above to model various COPCs and COPECs on an individual basis. Information from the hydrodynamic and sediment transport/organic carbon cycling models was passed forward to RCATOX to be used along with descriptions of contaminant partitioning to organic carbon and other contaminant processes (*e.g.*, volatilization, degradation, etc.) to determine contaminant concentrations in the overlying water and sediment.

The mechanistic models agreed with the results of the EMB model analysis described above, that resuspension of FFS Study Area sediments from tidal activity and scouring during high flow events is the primary ongoing source of COPCs and COPECs to the water column and surface sediments of the FFS Study Area as compared to the Upper Passaic River, Newark Bay, tributaries, CSOs and SWOs.

Assessment of Risk

Results of the human health risk assessment (HHRA) determined that the cancer risks to individuals based on the reasonable maximum exposure (RME) are substantially greater than the risk range established in the National Contingency Plan (NCP) of 10^{-4} (one in ten thousand) to 10^{-6} (one in one million) and that the non-cancer health hazards are much higher than the Superfund protection goal of a Hazard Index of one (HI equals one). Dioxins and PCBs are the primary contributors to the excess human health risk and non-cancer health hazard for ingestion of both fish and crab.

The ecological risk assessment (ERA) determined that the risks estimated for each category of ecological receptor evaluated (including benthic invertebrates, mummichogs, blue crabs, white perch, American eel, piscivorous birds like the great blue heron, and mink) produced hazard

⁷ Consolidation occurs when weight is applied to sediments that causes sediment particles to pack together more tightly.

⁸ Cohesive sediment is fine sediment particles that tend to stick together.

quotients (HQs) that were substantially greater than one. Dieldrin, dioxins, PCBs, copper and mercury are the primary contributors, depending on the receptor evaluated.

Details of the human health and ecological risk assessments will be presented in the RI.

Need to Address Unacceptable Risks

The sediments of the FFS Study Area are highly contaminated in the bioavailable, top six inches and become even more highly contaminated with depth. The inventory of contaminated sediments in the FFS Study Area is estimated at nearly 9.6 million cy. Contaminant concentrations in recently-deposited sediments have not declined significantly in the past 15 years. Resuspension of FFS Study Area sediments from storm events and tidal activity contribute to the contamination in surface sediments and biota in the rest of the Lower Passaic River and Newark Bay, posing unacceptable impacts to humans and the environment. Therefore, USEPA completed this FFS to evaluate remedial alternatives for an action to address those sediments.

Focused Feasibility Study (FFS) Overview

Remedial Action Objectives and Preliminary Remedial Goals

Remedial action objectives (RAOs) for the FFS Study Area are as follows:

- Reduce cancer risks and non-cancer health hazards for people eating fish and shellfish by reducing the concentrations of COPCs in the sediments of the FFS Study Area.
- Reduce the risks to ecological receptors by reducing the concentrations of COPECs in the sediments of the FFS Study Area.
- Reduce the migration of COPC- and COPEC-contaminated river sediments from the FFS Study Area to upstream portions of the Lower Passaic River and to Newark Bay and New York-New Jersey Harbor Estuary.

In accordance with Superfund guidance (Land Use in the CERCLA Remedy Selection Process, OSWER Directive No. 9355.7-04), reasonably anticipated future land and waterway use in the FFS Study Area will be considered during the development of remedial alternatives and remedy selection. There is an authorized navigation channel in the FFS Study Area that has not been maintained since the 1950s-1983. Various physical constraints, such as shallow depths and low vertical clearance bridges, limit commercial use of most of the navigation channel. However, the lower two miles of the river are used for commercial navigation by a number of petroleum

companies. A berth-by-berth analysis for 1997-2006 done by USACE establishes current waterway use and a USACE survey of commercial users in 2010 showed clear future waterway use objectives in the lower two miles of the river. The remedial alternatives should take into account these current and reasonably anticipated future navigational uses of the river.

In addition, the communities along the banks of the FFS Study Area have clearly planned for future increases in recreational access to the river, particularly above RM2, through master plans.

The RAOs, along with the reasonably anticipated future land and waterway use objectives, are considered during the development and evaluation of remedial alternatives.

Preliminary Remediation Goals (PRGs) are being developed for sediment and fish media to protect the human and ecological receptors evaluated in the risk assessments. They are being compared to background concentrations coming over Dundee Dam, since USEPA guidance also provides that "... the CERCLA program, generally, does not clean up to concentrations below natural or anthropogenic background levels." More details on PRGs will be provided in the FFS.

Description of Remedial Alternatives

Common Elements Included in All Alternatives

All of the alternatives contain some common elements that are considered in the evaluation process. Some elements are only shared by the "active" alternatives (i.e., alternatives other than "No Action"), as indicated below.

Institutional Controls: Existing institutional controls (e.g., NJDEP fish and shellfish consumption advisories) will continue under all of the alternatives. Outreach to educate community members about the NJDEP consumption advisories and to emphasize that advisories will remain in place during and after remediation would be incorporated into the active alternatives. Outreach activities would focus on communities known to fish for consumption, with special emphasis on sensitive populations (e.g., children, pregnant women, nursing mothers). Additional institutional controls such as restrictions or special conditions (e.g., to protect the integrity of engineered caps) imposed on private sediment disturbance activities could also be implemented as components of the active alternatives.

Monitored Natural Recovery (MNR): MNR includes monitoring of the water column, sediment and biota tissue during and after construction of active remedial measures and modeling of

contaminant concentrations to determine the degree to which they are recovering to PRGs. Once active remediation is completed, deposition of sediment, originating from freshwater flow over Dundee Dam (contributing primarily PCBs and PAHs) and tidal exchange with Newark Bay (contributing primarily mercury), will subsequently determine the extent to which sediment surface in the FFS Study Area is recontaminated. Natural recovery processes will serve to reduce the degree of contamination associated with these deposited solids.

Dredging: Large debris identified during geophysical surveys would be removed first. The FFS conceptual design assumed that dredging would occur using a mechanical dredge fitted with an environmental clamshell bucket, although costs for a hydraulic dredge were also estimated. Based on the results of the Environmental Dredging Pilot Study⁹ conducted in the FFS Study Area, using an environmental dredge equipped with an 8 cubic yard Cable Arm® clamshell bucket, the production rate for each of the two primary mechanical dredges was conservatively estimated to be 2,000 cubic yards per 24-hour day. A secondary dredge would operate at a lower production rate around obstructions such as bridge abutments and bulkheads. Dredging was assumed to occur for 40 weeks per year to account for equipment maintenance, weather and a period during which work may halt to allow for fish migration (known as a fish window). During the remedial design phase of the project, a fish migration study would be conducted to better define the fish window. The results of the Pilot Study indicated that over 70 percent of the targeted area was dredged to within six inches of the target elevation for single pass production dredging. Therefore, for current remedial work, a vertical accuracy of six inches and a one-foot over-dredging allowance was assumed. When the existing navigation channel was constructed in the 1880s-1910s, dredging accuracy was more typically one foot and over-dredging allowance two feet. Where volume estimates were based on the depth of the existing navigation channel, historical accuracy and over-dredging depth were used.

Capping or Backfill: Both capping and backfill material would consist of coarse-grained sand from nearby borrow sources. Cap or backfill material would be placed on the river bed using either a hydraulic diffuser or clamshell bucket. The term backfill is used for sand placed on the river bed after all contaminated fine-grained sediments have been removed, so that the sand layer's purpose is to mitigate the impact of any residual fine-grained sediment remaining after dredging. Backfill would not be monitored or maintained after placement, since the intent is not to leave behind any inventory of legacy contaminated sediments that could become mobile. On the other hand, an engineered cap is placed over contaminated fine-grained sediments to sequester them. An engineered cap would need to be monitored and maintained into the future. The thickness of the engineered cap would be designed to provide chemical

⁹ The Environmental Dredging Pilot Study was part of the comprehensive Lower Passaic River Restoration Project.

isolation, and allowance for consolidation, bioturbation and erosion protection. During design, appropriate enhanced capping technologies, such as additives to create an active cap, or thin capping technologies would be considered in areas where necessary or conducive to such approaches.

Removals: All alternatives assume that the Tierra Removal (Phase 1 and 2) and RM10.9 Removal will have been implemented, since they are governed by existing agreements.

Description of Remedial Alternatives

Alternative 1: No Action – The No Action alternative does not include any dredging, capping or backfill, disposal, or treatment of contaminated sediments, although the Tierra and RM10.9 Removals are assumed to have been completed. No Action includes continuation of existing institutional controls such as the NJDEP fish and shellfish consumption advisories, but excludes implementation of new controls. It involves only very limited monitoring for the purpose of performing the five-year reviews required by CERCLA Section 121(c). Cost = \$8.6 million.

Alternative 2: Deep Dredging with Backfill – Deep Dredging with Backfill involves dredging all fine-grained sediments throughout the FFS Study Area (9.6 million cy) and placing two feet of backfill. It results in the restoration of the authorized navigation channel. The sequence of dredging is from RM8.3 to RM0. Construction duration for this alternative is estimated to be 11 years.

Within the authorized navigation channel, the depth of fine-grained sediment corresponds well with the depth of historical dredging. Therefore, the depth of dredging is assumed to be the authorized channel depth plus an additional three feet to account for historical dredging accuracy and over-dredging. The resulting sediment removal depths (all in mean low water [MLW]) are:

- RM8.3 to 8.1: 13 feet (resulting in a 10-ft deep navigation channel) over a 150 ft width;
- RM8.1 to 7.1: 19 feet (resulting in a 16-ft deep navigation channel) over a 200 ft width;
- RM7.1 to 4.6: 19 feet (resulting in a 16-ft deep navigation channel) over a 300 ft width;
- RM 4.6 to 2.6: 23 feet (resulting in a 20-ft deep navigation channel) over a 300 ft width;
- RM2.6 to 0.0: 33 feet (resulting in a 30-ft deep navigation channel) over a 300 ft width.

Outside the horizontal limits of the navigation channel (in the shoals), the depth of fine-grained sediment varies. Core data were used to estimate depth of fine-grained sediments targeted for dredging (from 3 ft to 19.5 ft MLW). Final dredging depths would be refined in the remedial design phase of the project. Mudflats disturbed by implementation of Alternative 2 would be

reconstructed to their original grade and would include one foot of mudflat reconstruction (habitat) substrate.

As soon as practicable after dredging, two feet of backfill material will be placed to mitigate residuals. The backfill material will be placed in a series of lifts, with the first lift placed soon after dredging is completed in a given area to mitigate residuals, and the last lift placed over the entire FFS Study Area after all dredging is completed to mitigate re-contamination from dredging resuspension.

Dredged materials removed would be managed in accordance with one of three dredged materials management (DMM) scenarios described in more detail below.

- DMM Scenario A: Confined Aquatic Disposal (CAD)
- DMM Scenario B: Off-Site Disposal
- DMM Scenario C: Local Decontamination and Beneficial Use

As discussed above (“Common Elements”), institutional controls and MNR are implemented after construction until PRGs are met. The Tierra and RM10.9 Removals are assumed to have been completed.

Cost: Alternative 2 with DMM Scenario A = \$1.3 Billion
Alternative 2 with DMM Scenario B = \$3.4 Billion
Alternative 2 with DMM Scenario C = \$2.9 Billion

Alternative 3: Capping with Dredging for Flooding and Navigation – Capping with Dredging for Flooding and Navigation includes dredging of enough fine-grained sediment (4.3 million cy) to ensure that an engineered cap can be placed without causing additional flooding and to allow for a navigation channel in RM0.0-2.2. Dredging is followed by placement of an engineered cap (or backfill where appropriate, as described below) over the FFS Study Area. The sequence of dredging/capping is from RM0 to RM2.2, then RM8.3 to RM2.2 and then the Kearny Point mudflats. Construction duration for this alternative is estimated to be 6 years.

This alternative includes construction of a 300-foot wide navigation channel to the reasonably-anticipated future use depths in RM0.0-2.2, determined with reference to the 2010 USACE survey of commercial users described above. Where dredging depths coincide with the authorized navigation channel (RM0.0-1.2), an additional three feet are dredged to account for historical dredging accuracy and over-dredging, followed by placement of backfill. Where dredging depths are shallower than the authorized channel, an additional 5.5 feet are dredged to accommodate an engineered cap (to provide a cap protection buffer and allow for future

maintenance dredging). Resulting dredging depths are as follows (all in MLW, over a 300-ft width):

- RM0.0 to 1.2 = 33 ft (resulting in a 30-ft deep navigation channel);
- RM1.2 to 1.9 = 30.5 ft (resulting in a 25-ft deep navigation channel);
- RM1.9 to 2.2 = 25.5 ft (resulting in a 20-ft deep navigation channel).

In RM2.2-8.3, dredging is performed to a depth of at least 10 ft below MLW over a 200-ft width (except in RM8.1-8.3, where dredging will be over a 150-ft width) to prevent the engineered cap from causing additional flooding. This means dredging an additional 2.5 feet below MLW to accommodate the engineered cap. Final dredging depths may need to be refined in the remedial design phase of the project, and would include enough dredging to ensure cap stability and efficacy. There would be no channel maintenance in the future above RM2.2.

Mudflats disturbed by implementation of Alternative 3 would be reconstructed to their original grade and would include one foot of mudflat reconstruction (habitat) substrate.

Dredged materials removed would be managed in accordance with one of three DMM scenarios described in more detail below.

- DMM Scenario A: CAD
- DMM Scenario B: Off-Site Disposal
- DMM Scenario C: Local Treatment and Beneficial Use

As discussed above (“Common Elements”), institutional controls and MNR are implemented after construction until PRGs are met. The Tierra and RM10.9 Removals are assumed to have been completed.

Cost: Alternative 3 with DMM Scenario A = \$1.0 Billion
Alternative 3 with DMM Scenario B = \$1.9 Billion
Alternative 3 with DMM Scenario C = \$1.7 Billion

Alternative 4: Focused Capping with Dredging for Flooding – Focused Capping with Dredging for Flooding includes dredging of fine-grained sediments (894,000 cy) in selected portions of the FFS Study Area (223 acres) with the highest net flux of COPCs and COPECs to a depth of 2.5 feet so that an engineered cap can be placed over those portions dredged without causing additional flooding. It does not include construction of a navigation channel. The sequence of dredging and capping is from RM8.3 to RM0. Construction duration for this alternative is estimated to be 3 years.

Dredged materials removed would be managed in accordance with one of three DMM scenarios described in more detail below.

- DMM Scenario A: CAD
- DMM Scenario B: Off-Site Disposal
- DMM Scenario C: Local Treatment and Beneficial Use

As discussed above (“Common Elements”), institutional controls and MNR are implemented after construction until PRGs are met. The Tierra and RM10.9 Removals are assumed to have been completed.

Cost: Not evaluated, because Alternative 4 is not protective (see “Mechanistic Modeling to Evaluate Alternatives” section below).

Dredged Material Management (DMM) Scenarios

DMM Scenario A: Confined Aquatic Disposal (CAD) – Multiple CAD cells below the existing bathymetry would be constructed in Newark Bay, as shown in Figure 4-2. The conceptual design assumes that the first 5 to 15 feet of material excavated from the first CAD cell would be contaminated, resulting in disposal at an upland facility. For the remaining CAD cells, the first 5 to 15 feet of material is assumed to be disposed of in one of the previously-constructed CAD cells. Deeper, less-contaminated material (including approximately 45 feet of clay) would be disposed of in an ocean disposal area. The CAD site is assumed to be surrounded by a sheetpile containment system with silt curtains across the entrance channel to minimize impacts to Newark Bay during construction and dredged material placement.

Dredged material from the active alternatives is barged directly to the CAD site in a split hull or bottom bump barge and disposed of in the CAD cell under water. An engineered cap is placed over the dredged material as final cover. The final grade of the CAD cell would be consistent with the existing adjacent bathymetry.

To the extent practicable, the most-highly contaminated dredged material would be placed into the CAD cell first so that it would be confined in the deepest part of the cell, followed by less-contaminated material.

DMM Scenario B: Off-Site Disposal – Dredged materials from the active alternatives are barged to an upland sediment processing facility in the vicinity of the Lower Passaic River/Newark Bay shorelines for active dewatering using filter presses. The facility includes a water treatment plant. The dewatered materials are transported by rail to incinerators and/or landfills in the

U.S. and Canada for disposal. Several facilities have been identified as potentially having capacity to receive FFS Study Area dredged materials by rail.

DMM Scenario C: Local Decontamination and Beneficial Use – Dredged material from the active alternatives is barged to an upland sediment processing facility in the vicinity of the Lower Passaic River/Newark Bay shorelines. The material to be decontaminated using thermal treatment is actively dewatered using filter presses. The facility includes a water treatment plant. The material to be decontaminated using sediment washing is assumed not to need dewatering. Depending on the degree of contamination present and the remedial alternative, various proportions of the dredged materials are then decontaminated using a thermal technology or sediment washing, with beneficial use end-products.

At least four thermal treatment technologies have been identified as potentially able to treat FFS Study Area dredged sediments. Three have conducted pilot demonstrations with Passaic River-Newark Bay sediments and one conducted pilot demonstrations with Lower Fox River (Wisconsin) sediments. All achieved over 99 percent removal efficiencies for a variety of COPCs and COPECs, including dioxins, PCBs, PAHs and metals.

At least four vendors have developed sediment washing technologies. One conducted a pilot demonstration with Passaic River-Newark Bay sediments in 2005-06. The demonstration was operated at a treatment rate of 40 cy per hour (equivalent to 250,000 cy per year) and achieved variable removal efficiencies (ranging from less than 10 to 80 percent) for dioxins and furans, PCBs, PAHs and metals. While data from the demonstration was not conclusive that the system would be effective in treating all COPCs and COPECs to NJ standards that would allow the end product to be used beneficially without restrictions, it is possible that sediment washing, combined with solidification and stabilization technology, would enable the end product to be used as RCRA D landfill cover.

Mechanistic Modeling to Evaluate Alternatives

A LPR-NB model was developed that links hydrodynamics (ECOM), sediment transport (SEDZLJS), organic carbon (ST-SWEM) and contaminant fate and transport (RCATOX) processes. The four FFS alternatives described above were simulated with the model to evaluate future contamination concentrations in the sediments post-remediation. Modeling results will be described in detail in the FFS. In summary, Alternative 4 (Focused Capping with Dredging for Flooding) was screened out based on modeling projections that showed it would not result in post-remedial sediment concentrations that are protective of human health and the environment.

Detailed Analysis of Alternatives

During detailed analysis, the remaining three alternatives (No Action, Deep Dredging with Backfill, and Capping with Dredging for Flooding and Navigation) and associated dredged material management scenarios will be evaluated against the nine evaluation criteria set forth in the NCP that have been developed to address CERCLA requirements for selecting among remedial alternatives. The evaluation criteria are as follows:

- Overall protection of human health and the environment
- Compliance with applicable or relevant and appropriate requirements (ARARs)
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility or volume
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

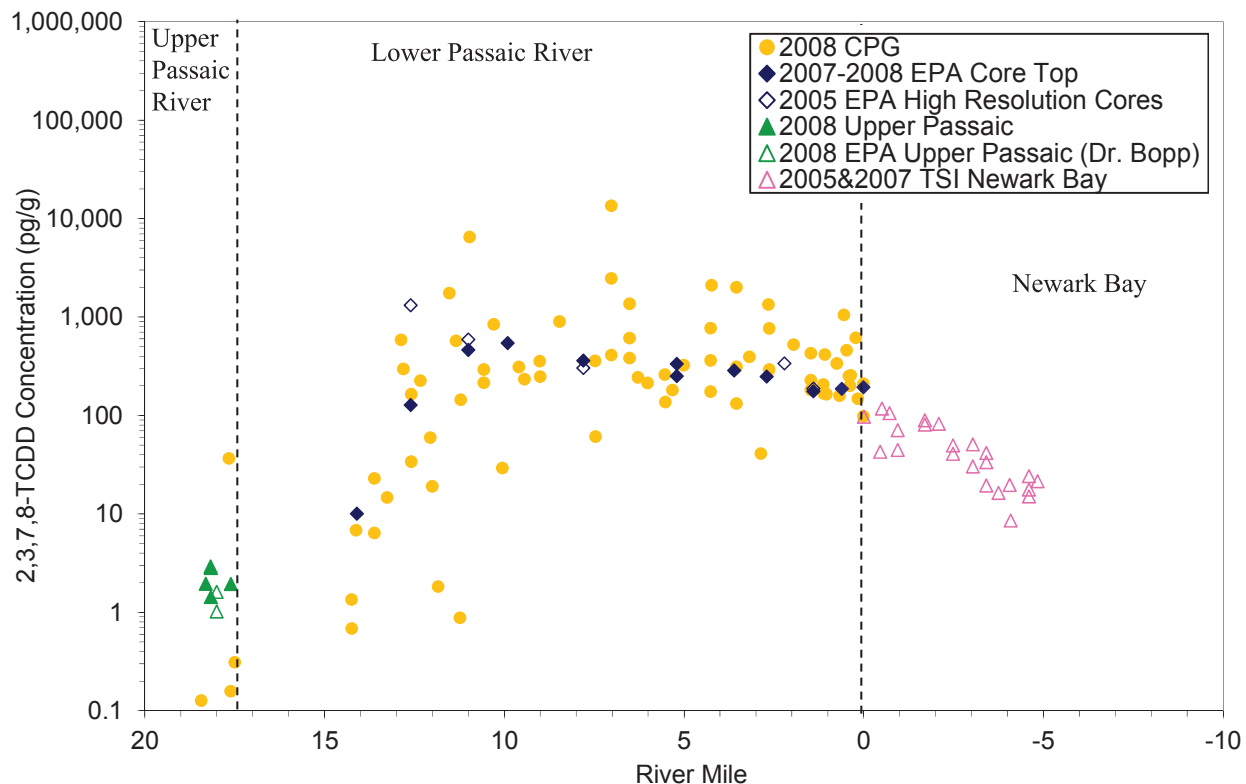
Results of this analysis, which is underway, will be described in detail in the FFS report.

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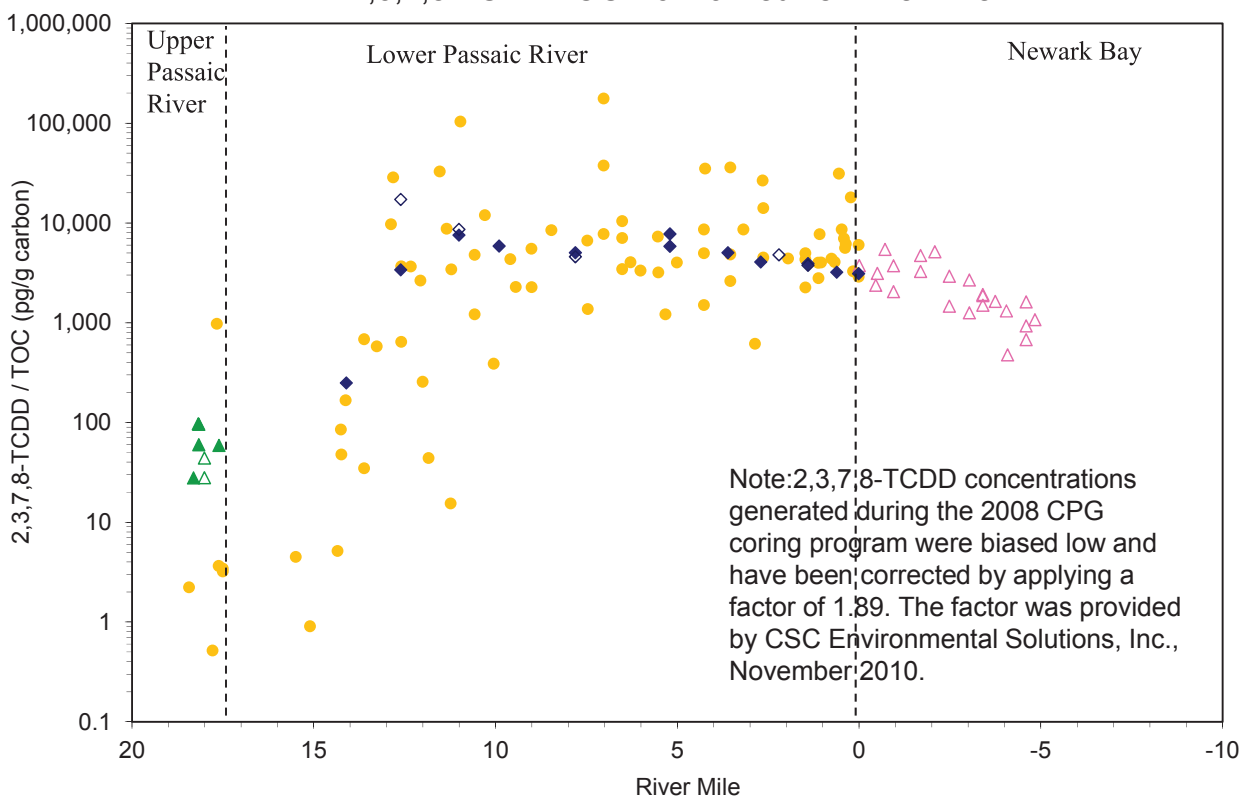


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2,3,7,8-TCDD vs. River Mile



2,3,7,8-TCDD TOC Normalized vs. River Mile



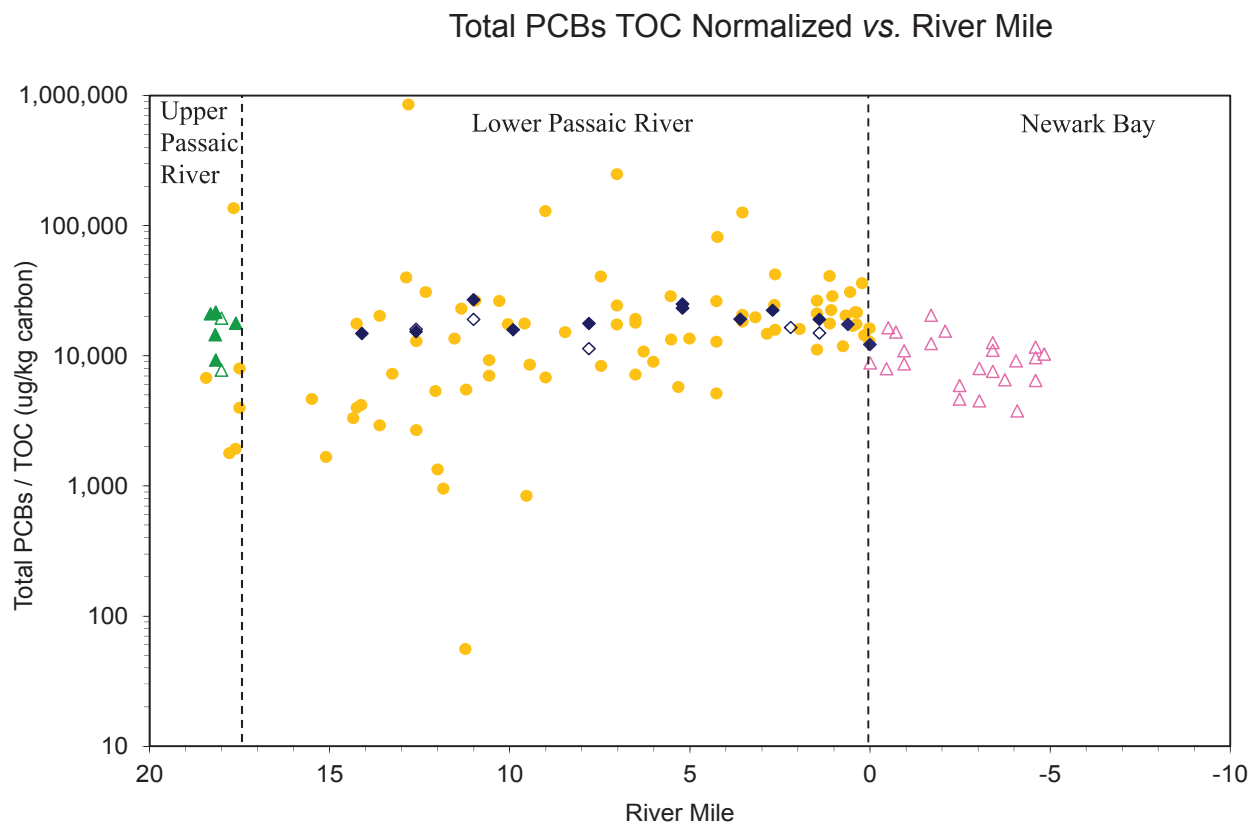
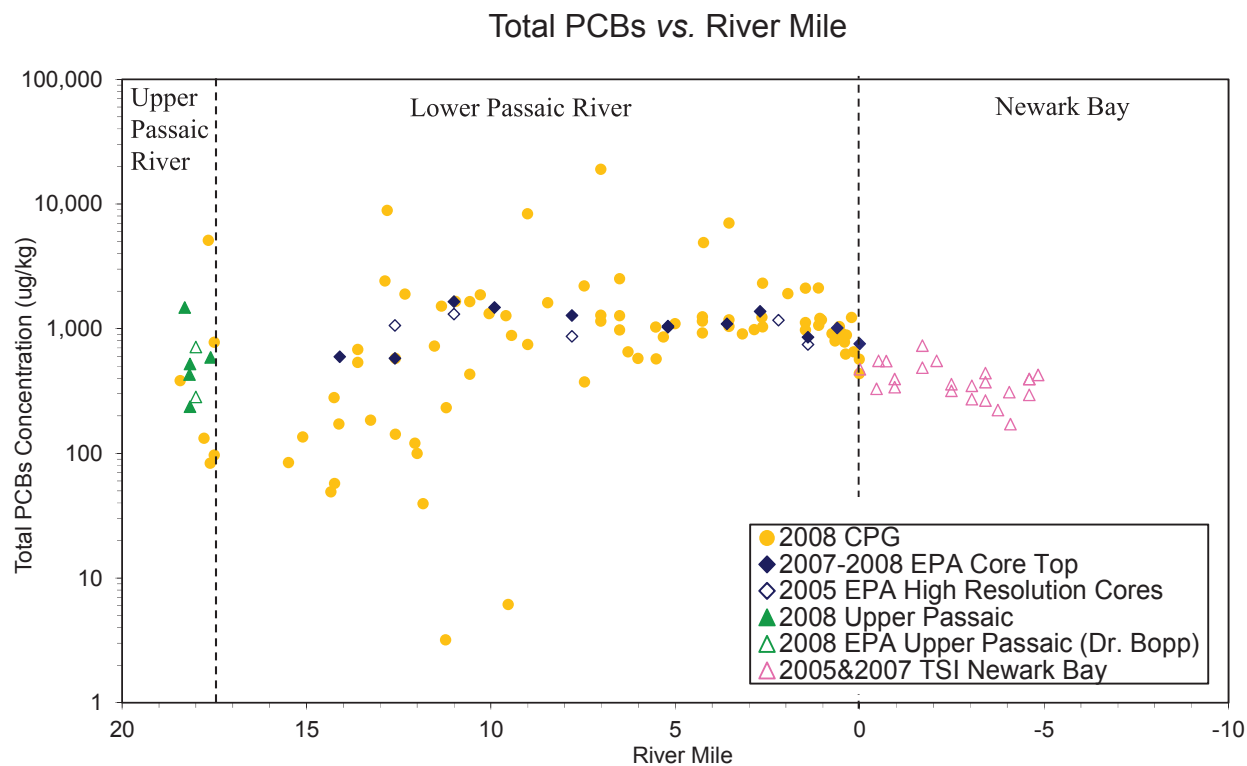
2,3,7,8-TCDD in Recently-Deposited Sediments in the Lower Passaic River, Newark Bay and the Upper Passaic River

Lower Passaic River Restoration Project

Figure 4-3

2012

R2-0024980



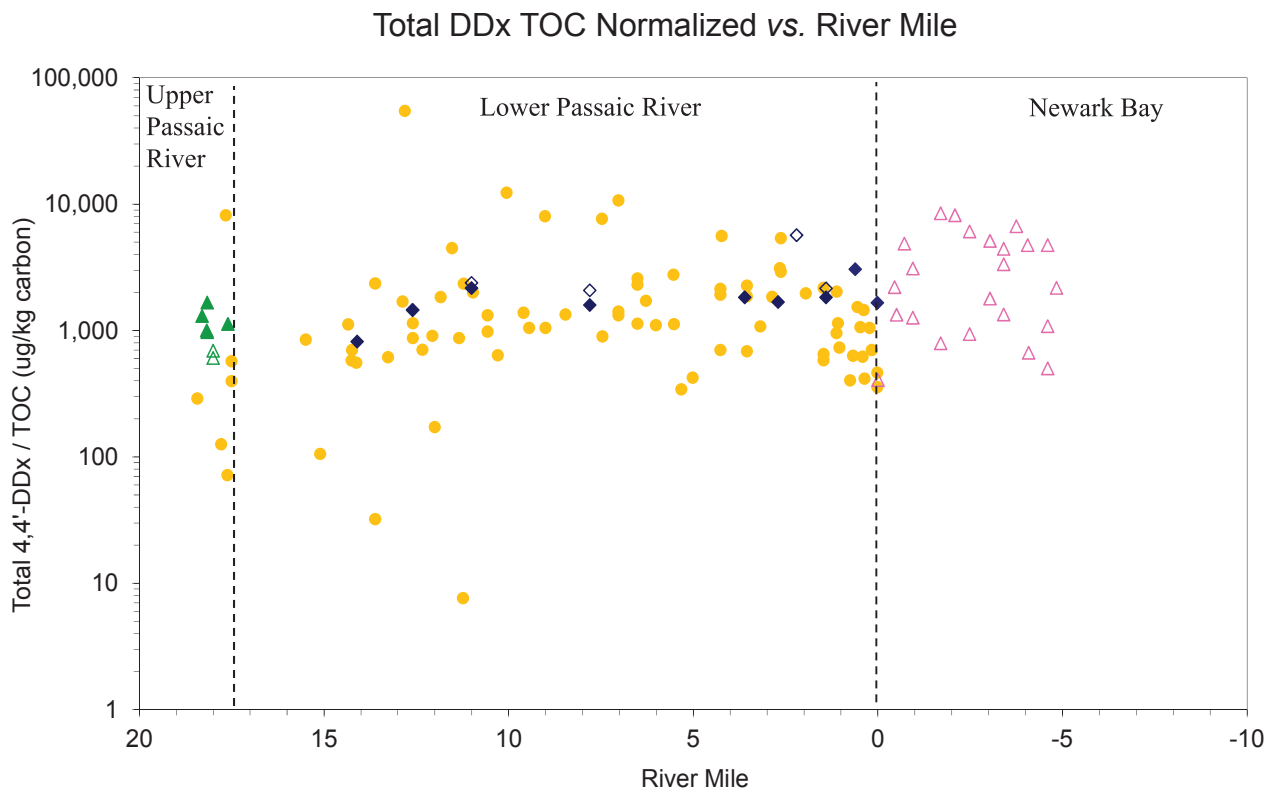
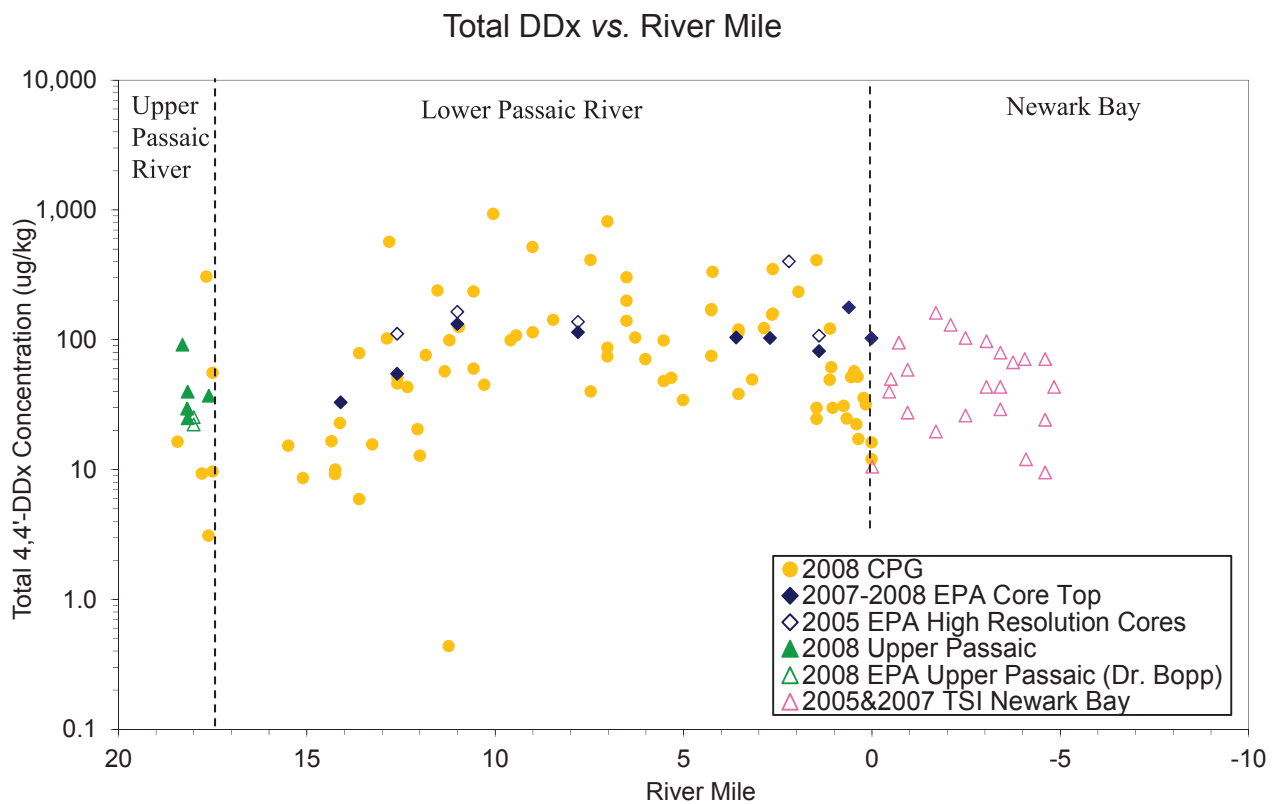
Total PCBs in Recently-Deposited Sediments in the Lower Passaic River, Newark Bay and the Upper Passaic River

Lower Passaic River Restoration Project

Figure 4-12

2012

R2-0024981



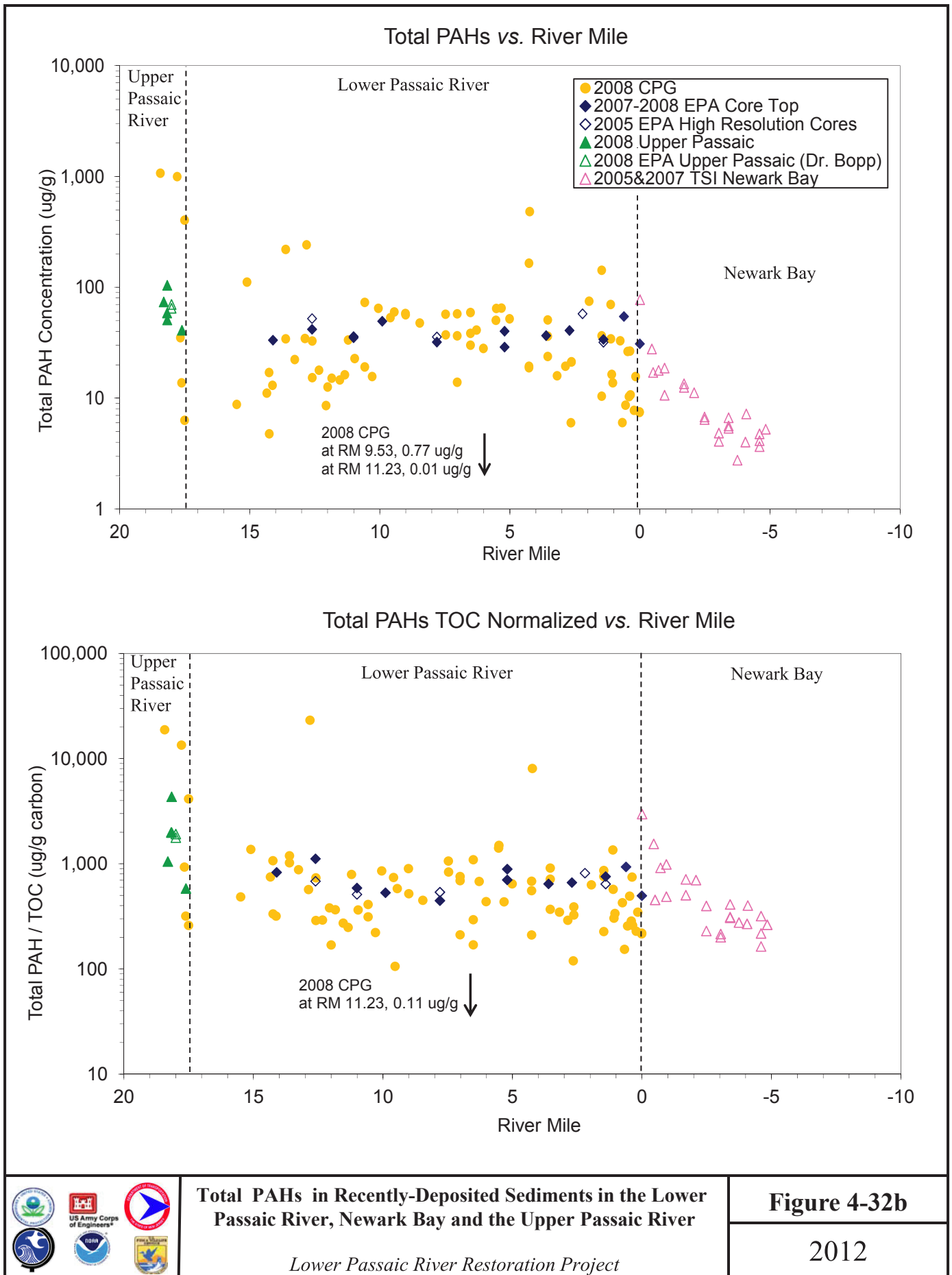
**Total DDx in Recently-Deposited Sediments in the
Lower Passaic River, Newark Bay and the Upper Passaic River**

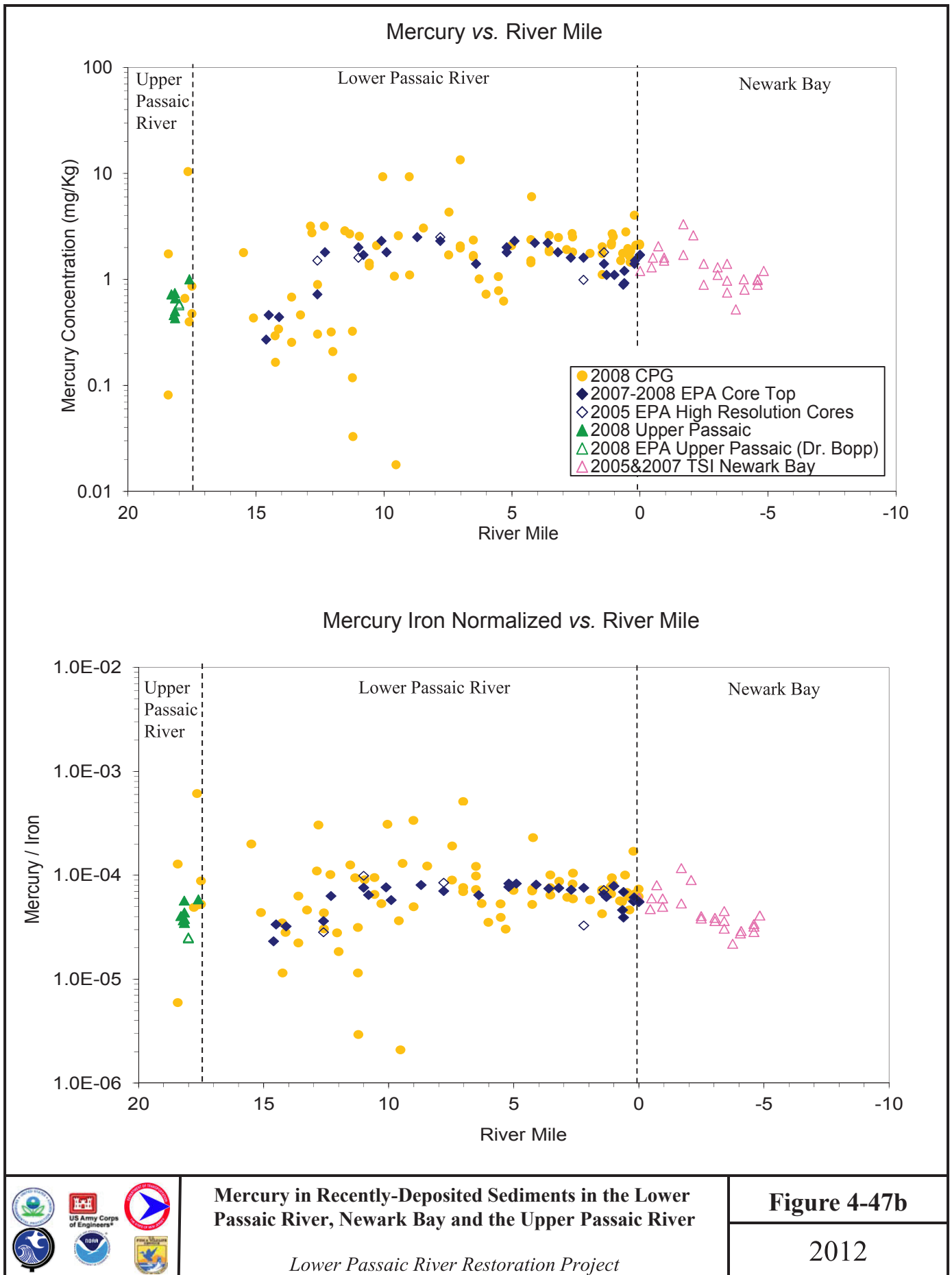
Lower Passaic River Restoration Project

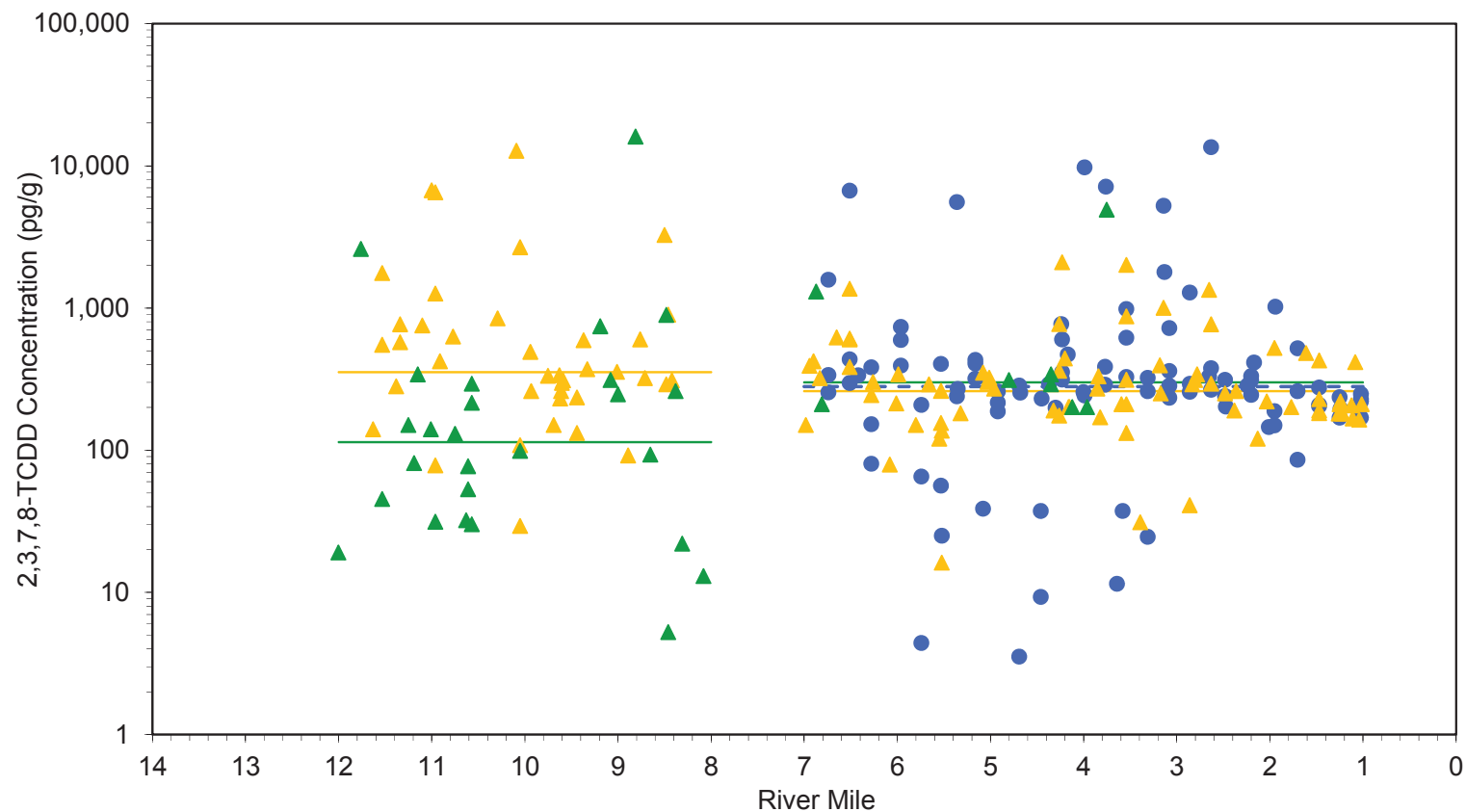
Figure 4-17b

2012

R2-0024982







Legend

- ▲ 2008-2010 Fine-Grained
- 2008-2010 Fine-Grained Median
- ▲ 2008-2010 Coarse-Grained
- 2008-2010 Coarse-Grained Median
- 1995
- - 1995 Median

Note: 2,3,7,8-TCDD concentrations generated during the 2008 CPG coring program were biased low and have been corrected by applying a factor of 1.89. The factor was provided by CSC Environmental Solutions, Inc., November 2010.



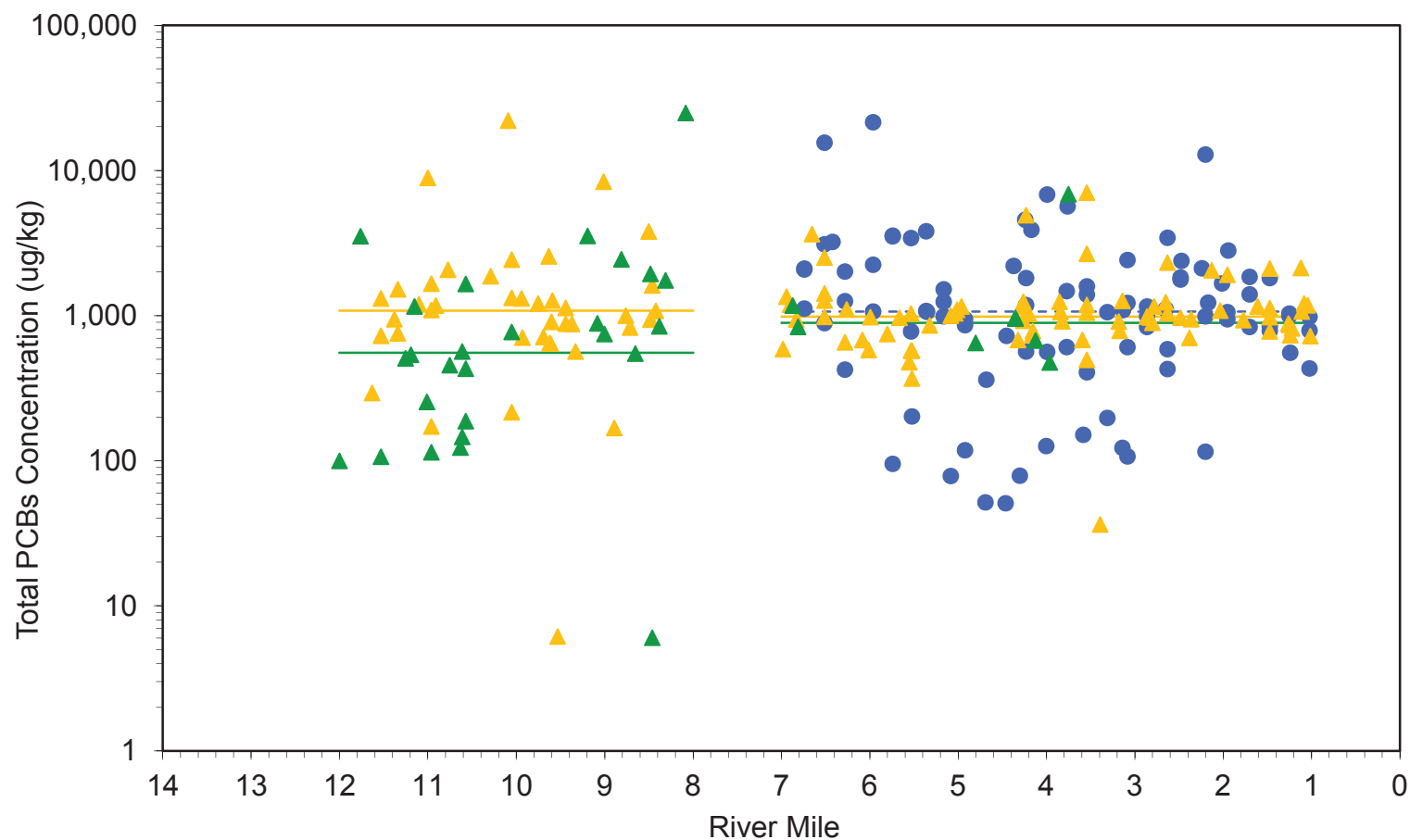
Comparison of 2,3,7,8-TCDD Surface Concentration (0-6 inches) RM1 to RM7 vs. RM8 to RM12

Lower Passaic River Restoration Project

Figure 4-4

2012

R2-0024985



Legend

- ▲ 2008-2010 Fine-Grained
- 2008-2010 Fine-Grained Median
- ▲ 2008-2010 Coarse-Grained
- 2008-2010 Coarse-Grained Median
- 1995
- - 1995 Median



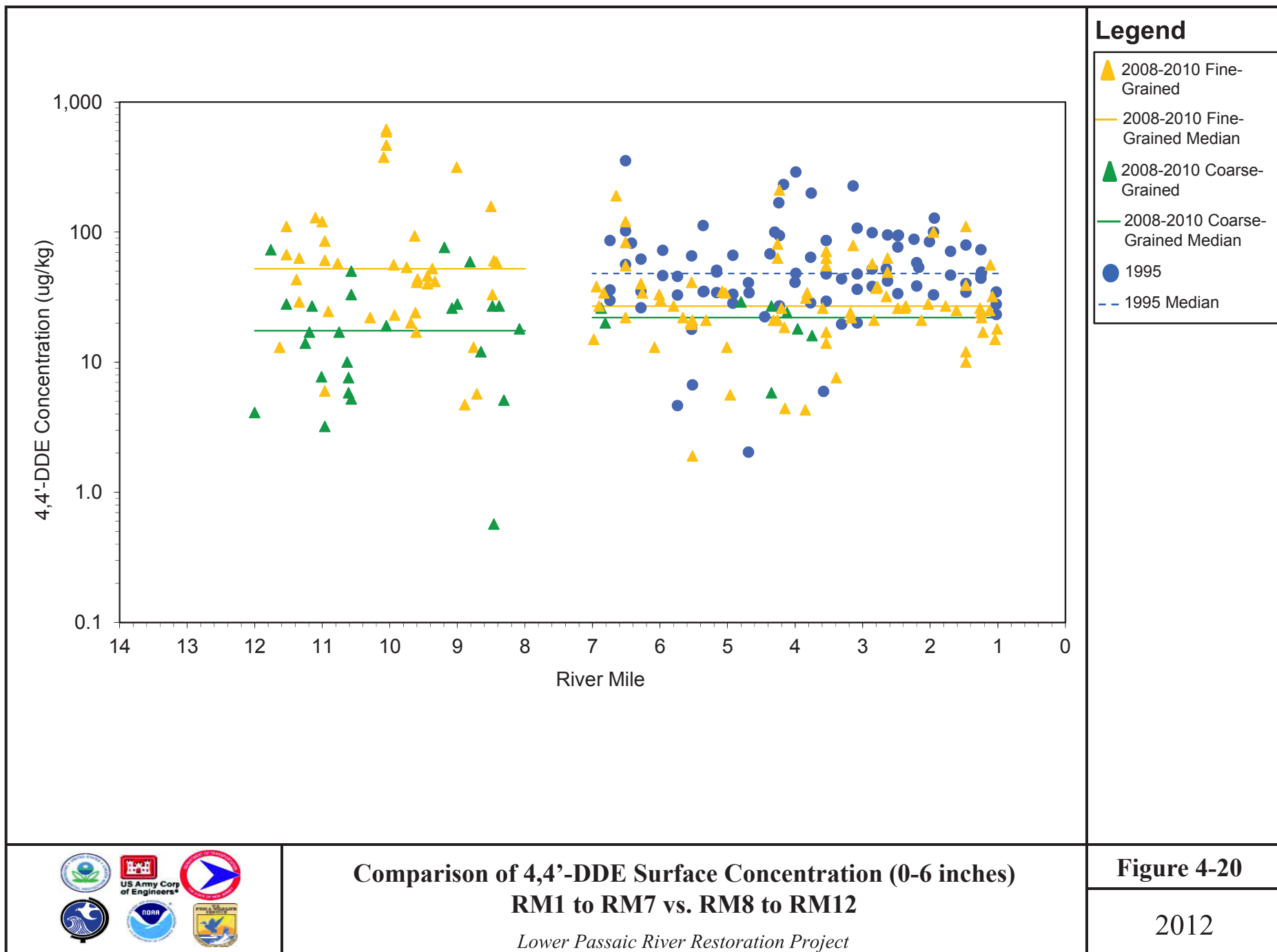
Comparison of Total PCBs Surface Concentration (0-6 inches) RM1 to RM7 vs. RM8 to RM12

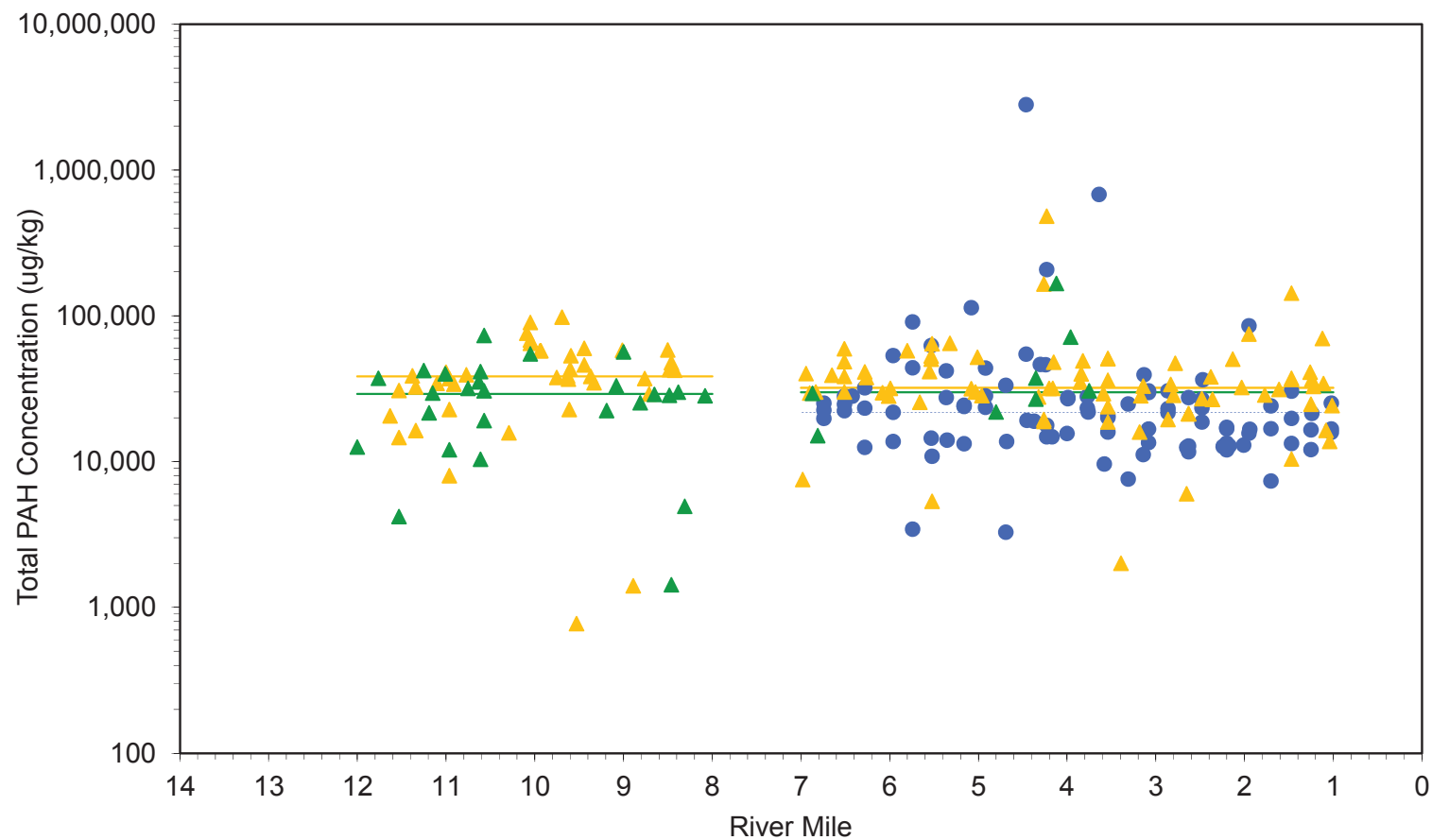
Lower Passaic River Restoration Project

Figure 4-13

2012

R2-0024986





Legend

- ▲ 2008-2010 Fine-Grained
- 2008-2010 Fine-Grained Median
- ▲ 2008-2010 Coarse-Grained
- 2008-2010 Coarse-Grained Median
- 1995
- 1995 Median

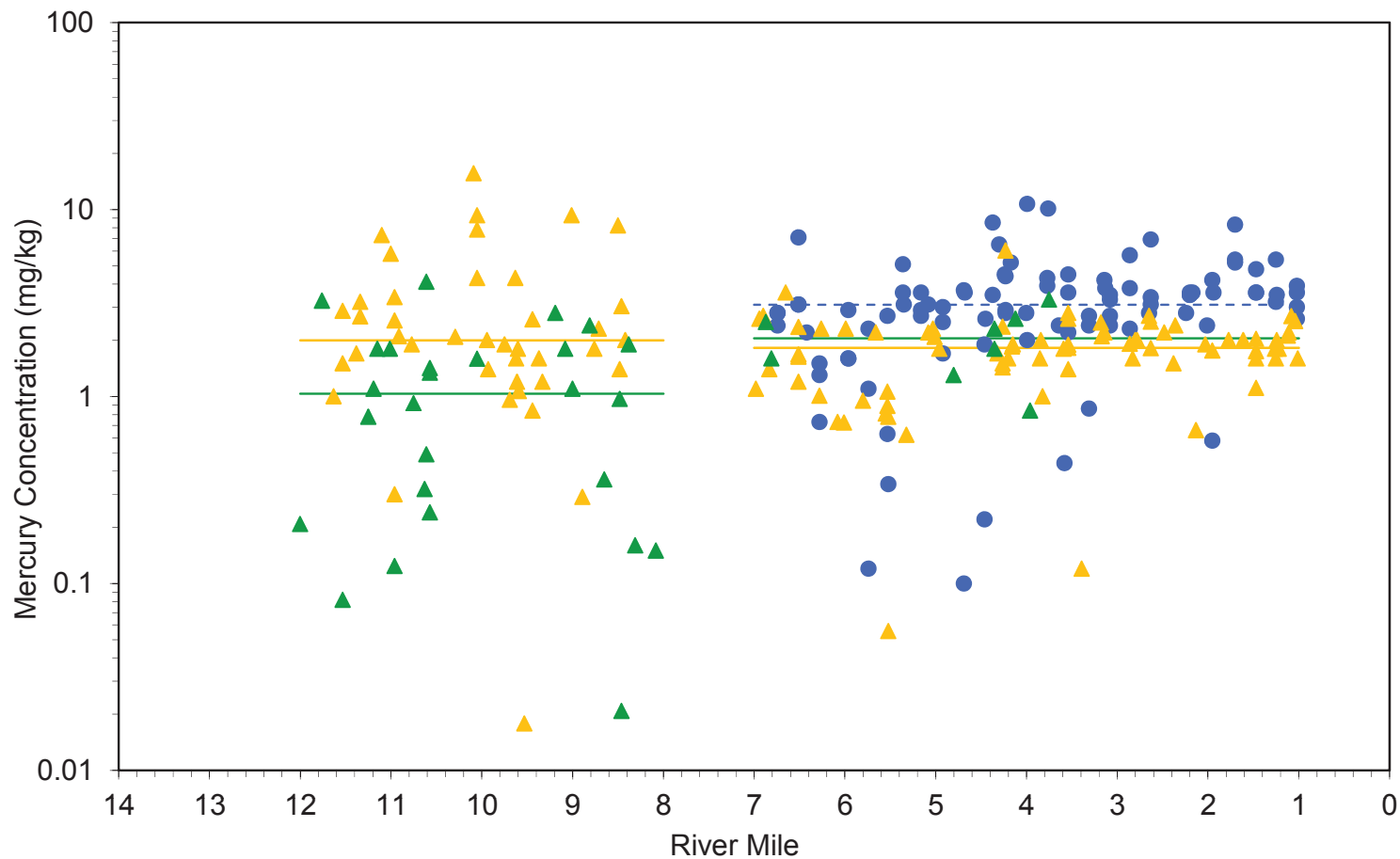


Comparison of Total PAHs Surface Concentration (0-6 inches) RM1 to RM7 vs. RM8 to RM12

Lower Passaic River Restoration Project

Figure 4-35

2012



Legend

- ▲ 2008-2010 Fine-Grained
- 2008-2010 Fine-Grained Median
- ▲ 2008-2010 Coarse-Grained
- 2008-2010 Coarse-Grained Median
- 1995
- - 1995 Median

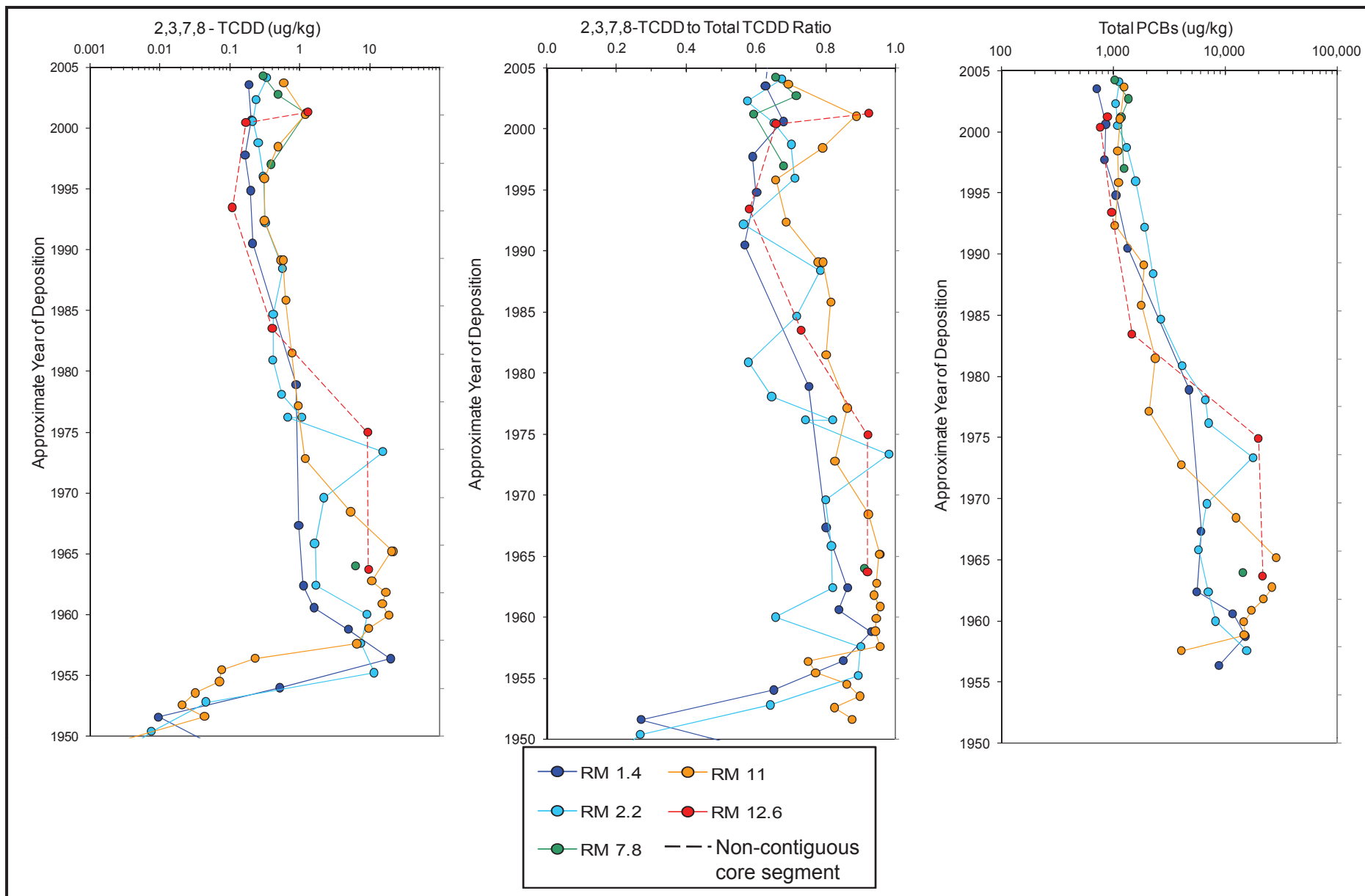


Comparison of Mercury Surface Concentration (0-6 inches) RM1 to RM7 vs. RM8 to RM12

Lower Passaic River Restoration Project

Figure 4-52

2012



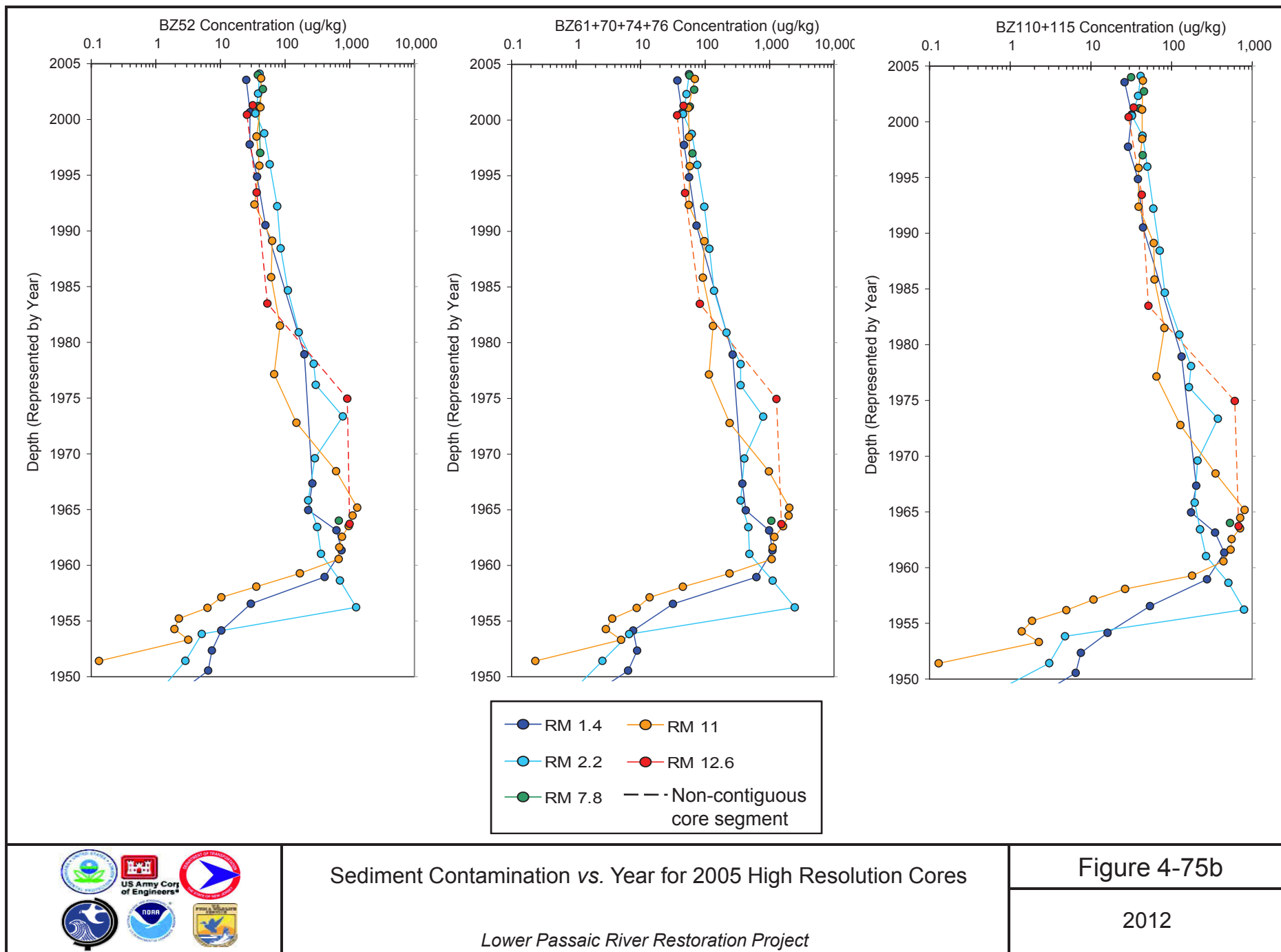
Sediment Contamination vs. Year for 2005 High Resolution Cores

Lower Passaic River Restoration Project

Figure 4-75a

2012

R2-0024990

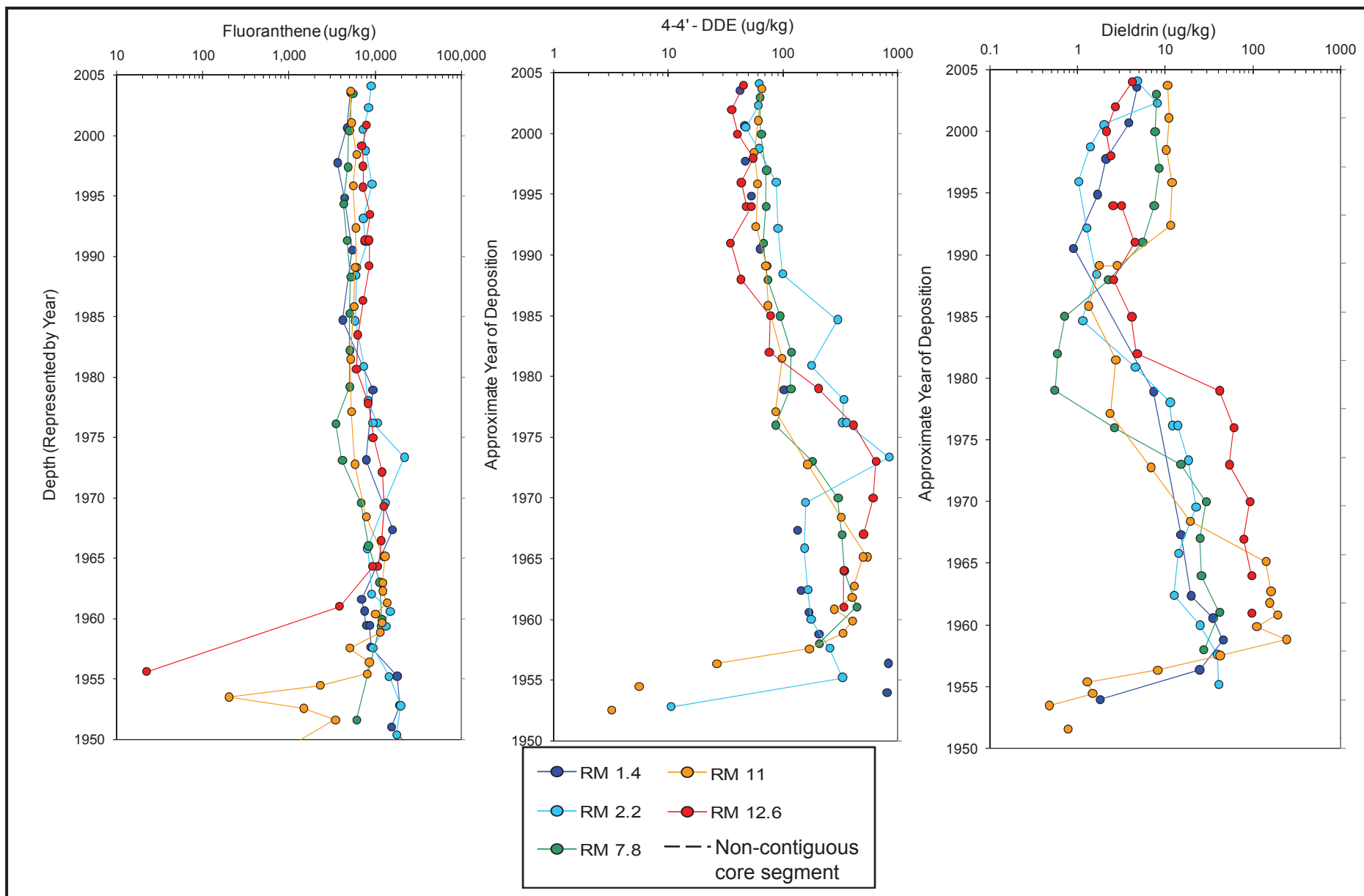


Sediment Contamination vs. Year for 2005 High Resolution Cores

Lower Passaic River Restoration Project

Figure 4-75b

2012



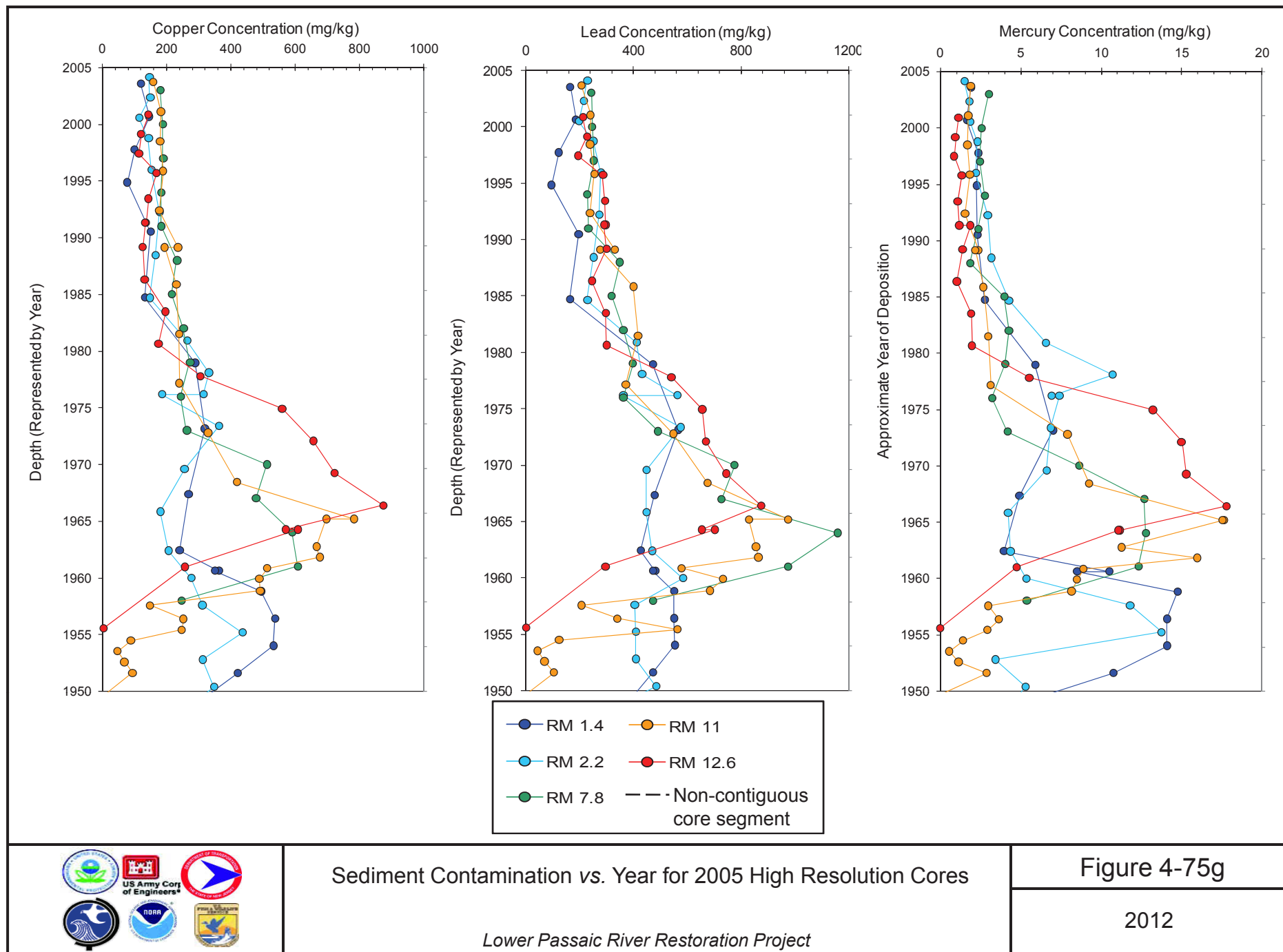
Sediment Contamination vs. Year for 2005 High Resolution Cores

Lower Passaic River Restoration Project

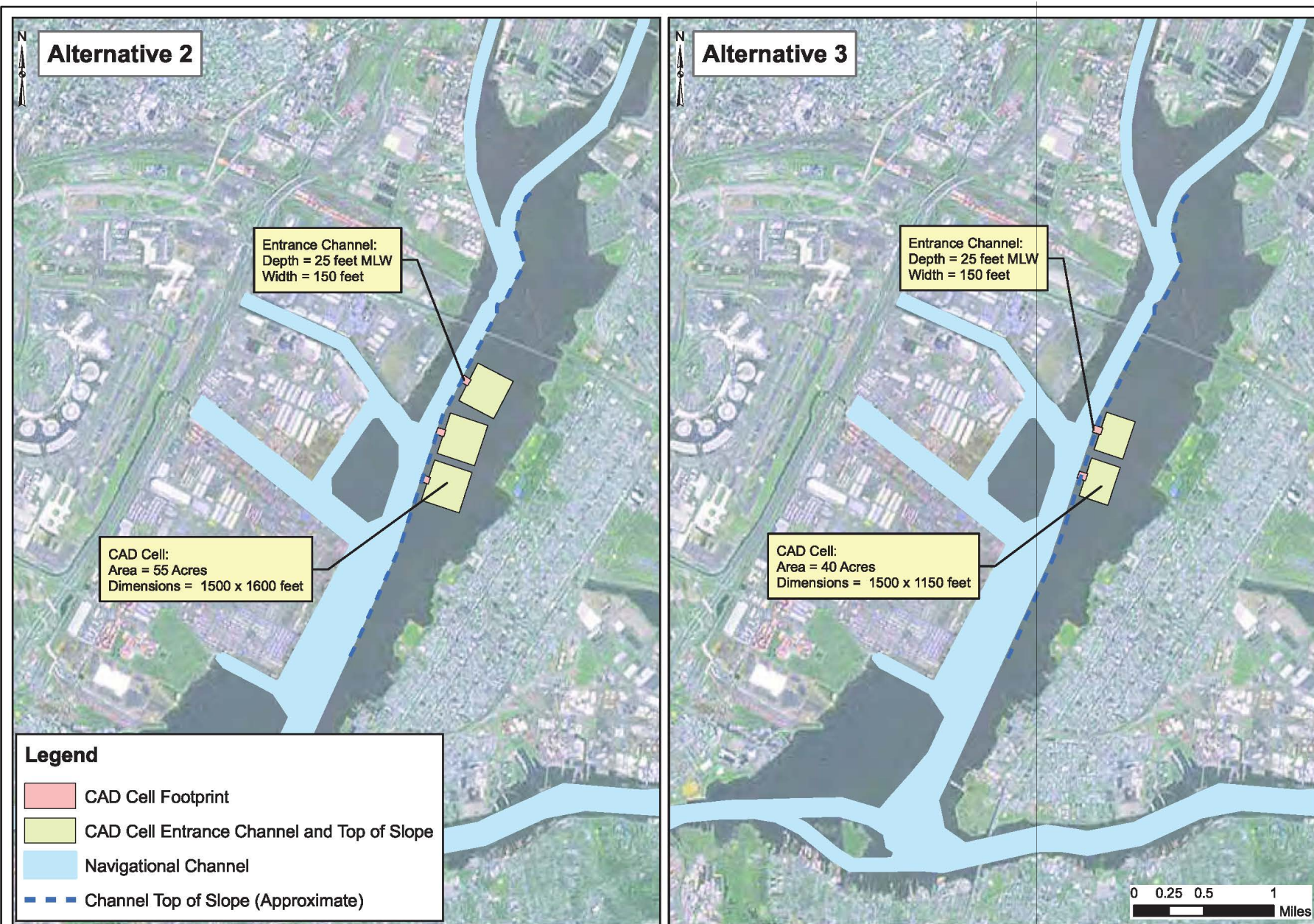
Figure 4-75e

2012

R2-0024992



s:\passaic\mapdocuments\Final_FFS_Figures_2013\Figure4-2 Proposed Confined Aquatic Disposal Cells in Newark Bay.mxd



Proposed Confined Aquatic Disposal Cells in Newark Bay

Lower Eight Miles of the Lower Passaic River

Figure 4-2

2013

R2-0024994